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Bridging the Methodological Gap Between the Physical and Social Sciences: Complexity Theory and Mixed Methods

Abstract
This paper explores the value of using mixed methods to apply complexity theory to the study of public policy. It seeks to combine mathematical modelling, to identify complex systems and model their effects, with qualitative techniques, to understand what this means in practice to policy participants. Complexity theory suggests that we shift our analysis from individual parts of a political system to the system as a whole; as networks of elements that interact, share information, adapt and combine to produce systemic behaviour. Key questions include: how much information do we need to generate a model to capture the essence of political system behaviour; what is the nature of the network that links its members; what types of systemic outputs occur when its members follow the same rules; and how sensitive is the system, or what small changes in rules will produce profound changes in systemic behaviour? In particular, the paper explores the rules of information processing within government departments, arguing that a mathematical model of this process is incomplete without the more in-depth knowledge of institutional rules that qualitative methods, such as elite interviewing and participant observation, provide.

Introduction
This paper arises from my experience of an interdisciplinary group at the University of Aberdeen. It recounts the various plans produced by the group and examines critically the steps required to make such plans successful. It describes a process of initial excitement when a range of academics come together to find that they have a common language and research agenda, followed by a more realistic take on the limits to their ambitions, and perhaps a third stage in which the excitement has gone and the lure of a return to single disciplines becomes stronger. The paper suggests that part of the stumbling block for advance is that the project was theory rather than problem driven; it perhaps represented a means to extend basic complexity theory from the natural sciences than to address a problem identified in political science. However, the themes discussed are still applicable to most projects that bring together academics with different research backgrounds, training, assumptions, and methods. The plan of the paper is as follows. First, it defines complexity theory. Second, it outlines the plans the group had to apply it in political science. Third, it summarises the theoretical problems (outlined more fully by a companion PSA paper – Cairney, 2010) that arise when we try to adapt complexity theory to the study of public policy. Fourth, it gives a flavour of the methodological and practical problems that arise when we try to turn an idea into a concrete project. Finally, it provides a brief outline of the qualitative research used to inform mathematical modelling.

What is Complexity Theory?
Complexity theory may be seen as 'a way of thinking, and a way of seeing the world' (Mittleton-Kelly, 2003: 26). For Sanderson (2006: 117) it developed as a consequence of seeing the world differently, as a 'world of instability and fluctuations' when in the past it

was seen as 'stable'. According to Mitchell (2009: x), it represents a revolutionary break from the 'reductionist' approach to science. The approach seeks to explain why complex or system-wide behaviour emerges from the interaction between 'large collections of simpler components' (2009: x; Kernick, 2006; Blackman, 2001). Different accounts identify different factors, or place more emphasis on some at the expense of others. There is also some doubt about the unity of the theory, with Mittleton-Kelly (2003: 23) in particular arguing that it is really a collection of theories from a variety of disciplines in the natural and social sciences (and there are variants, such as theories of complex adaptive systems). This makes the identification of its key tenets difficult. However, the paper identifies six common assumptions regarding how complex systems behave and how we should study them:

1. A complex system cannot be explained merely by breaking it down into its component parts because a key element of system dynamics is the manner in which those elements interact with each other. Instead, we must shift our analysis to the system as a whole; as networks of elements that interact, share information, adapt and combine to produce systemic behaviour.
2. The behaviour of complex systems is difficult to predict. Complex systems exhibit non-linear dynamics produced by feedback loops in which some forms of energy or action are dampened (negative feedback) while others are amplified (positive feedback). As a result, small actions can have large effects and large actions can have small effects. This suggests that periods of equilibrium are also unstable because a small input of energy can have a large effect. This can be linked to the term 'phase transitions', which describes the tipping point at which dramatic change results from the marginal effect of energy (such as when a liquid becomes gas).
3. Complex systems are particularly sensitive to initial conditions which produce a long-term momentum, suggesting that any small measure in initial measurement, or failure to account for the effect of seemingly insignificant factors will produce major errors in predictions of future behaviour (the 'butterfly effect').
4. They exhibit emergence, or behaviour that evolves from the interaction between elements at a local level rather than central direction. This makes the system difficult to control.
5. They may contain 'strange attractors' or demonstrate extended regularities of behaviour (Bovaird, 2008: 320). They may therefore exhibit periods of 'punctuated equilibria' - in which long periods of stability are interrupted by short bursts of change - such as when new species emerge suddenly in the process of evolution.
6. The various problems that complexity theory seeks to address – such as predicting climate change, earthquakes, the spread of disease among populations, the processing of DNA within the body, how the brain works, the growth of computer technology and artificial intelligence, and the behaviour of social and political systems – can only be solved by interdisciplinary scientific groups (Mitchell, 2009: x).

In this light, a complex system is a large number of elements that interact with each other to produce system-wide behaviour. This process cannot be understood simply by breaking it down into its individual elements. For example, swarming behaviour in bees and coordinated behaviour in ants cannot be explained merely by the actions of individual insects. Rather, we must study their actions as a whole, the rules they follow, how those rules are communicated and the extent to which a small change in rules causes a large systemic change. The brain is also a complex system in which emergent processes, such as thoughts and feelings, are difficult to break down into the performance of individual neurons.

There may also be some intuitive resonance with public policy processes. Complex systems display behaviour that is difficult to predict or control. It is difficult to predict because it is 'non-linear': the effects of some actions are dampened but others amplified - such as when a policymaker ignores one source of information but responds to another. It is difficult to control centrally because behaviour seems to emerge from the interaction between agents at a local level - such as when service delivery organisations make policy as they implement it. The concern regards whether or not we can take that intuitive recognition of processes and apply complexity theory in a more meaningful way; identifying complex systems rather than using the idea as a metaphor.

Complexity Theory and Interdisciplinary Language

The following section represents a summary of the basic interdisciplinary project (as written by the group). The Institute for Complex Systems at the University of Aberdeen represents the development of an integrated community of mathematicians, physicists, biologists, zoologists and social scientists who are working on complex networks. Its initial projects developed links between mathematicians in the physics department with colleagues from biological sciences. It also pursued work on analysing the brain as a complex network or system. A subsequent project brought together academics from physics, economics, philosophy and political science and its broad aim was: to provide the common ground and tools necessary for synergistic interactions of researchers in different disciplines. The development recognises that complex networks theory spans many disciplines and will seek to foster the widest applications of such analyses. This project aims in particular to introduce mathematical reasoning and models to the study of tipping points in political science and compare the results with empirical investigations and philosophical analysis.

Its contributors work on the common assumption that: (a) the term 'complex network' refers to graphs (sets of objects where some pairs are connected by links) exhibiting a type of non-trivial topology that does not occur in regular or totally random networks; and (b) theoretical research on complex networks has triggered an explosion of interest in the subject in recent years, mainly due to the broad applicability of the results to different disciplines, leading to major advances in the field. Network theory has been successfully applied in many areas, such as neuroscience, sociology, ecology, epidemiology, memory coding, computer networks, metabolic networks and community networks (Newman et al, 2006; beim Graben et al, 2008; Motter et al, 2002; Arenas et al, 2008). The Institute has established a strong research base in the analysis of complex networks through the development of new basic theory and applications to different fields of science and technology (Moura et al, 2003). We now propose to advance our understanding of political behaviour by focusing on the relatively under-developed applications of network analysis to political science and the study of tipping points, specifically:

- How can we *predict* tipping points using complex systems theory and game theory?
- How can we *explain* tipping points using empirical research?
- What does tipping point *mean* in the socio-political context?

To answer these questions, we will work closely together to continue the development of basic theory and ally this to empirical and philosophical work in the analysis of political systems. The mathematics of complex systems, extreme events, complex networks and self-organised criticality will be at the heart of the modelling process of this system. The different behaviour of the system in distinct circumstances might be described by path dependent behaviour or by plastic networks, i.e., networks in which the topology changes in time. The

translation of situations found in the social and political sciences into a mathematical language is a challenging problem, but offers huge potential benefits for our society.

Theoretical Problems

The theoretical problems arising from attempts to apply complexity theory to public policy are outlined more fully in the companion to this paper (Cairney, 2010). These can be summarised as follows:

1. Complexity theory is difficult to pin down. Its appeal across the sciences may be because it means different things to different people, suggesting that initial enthusiasm and cross-disciplinary cooperation may be replaced by growing scepticism when we move from the metaphor to the identification of complex systems.
2. When we do pin down the meaning of complexity theory, it seems to present a deterministic argument. The danger is that if the complex *system* is predominantly the causal factor then we lose sight of the role that policymakers play; there may be a tendency to treat the system as a rule-bound structure which leaves minimal room for the role of agency.
3. It is difficult to identify or define a complex system and separate it from its environment.
4. It is difficult to determine the most appropriate level of analysis – for example, are we talking about an organisation, a healthcare system, a political system or an international political system?
5. It is difficult to know which types of policy issue or area complexity theory applies to. There is some suggestion that it applies most to 'wicked issues' and least to areas characterised by command-and-control, but this is by no means clear.
6. Although anti-reductionism and whole-systems approaches sound attractive, reductionist theories have a strong hold in political science. Further, although complexity theory recommends seeing the world in terms of complex systems, limitations to research and cognitive ability force us to break it down into smaller units more amenable to study. As Teisman and Klijn (2008: 291) suggest, 'an analysis based on the complexity theory can focus on very specific and unique (in time and place) processes such as infrastructural and urban renewal and on more aggregated levels such as the health care system in a country and that both tell a part of a whole story and *neither of them is able to tell the whole story or even the main part of what is really going on*.'.
7. Complexity theory may merely complicate rather than improve the existing body of knowledge. So far, its conclusions regarding the role of public managers and the need to tread carefully when piloting new policies are not significantly different from conclusions in the old implementation and incrementalism literatures.

To some extent it may be unfair to damn complexity theory with charges that could apply to much of the literature. The ambiguity of language to describe political institutions and processes, the problems we encounter when trying to identify an appropriate level of analysis and the necessity of reductionism and partial stories is a feature of political science as a whole. The charge of determinism is also one that most studies in political science encounter when they go beyond individual intentions towards the study of ideas, structures and rules. Further, as Haynes (2008: 402) suggests, these are issues that are increasingly addressed within the complexity literature.

Philosophical, Methodological and Practical Problems

Proponents of complexity theory offer a very attractive mixed-methods approach in which methodological pluralism is encouraged. For example Butler and Allan (2008: 434) describe a 'hybrid methodological position in which both narrative and mechanical descriptions contribute to understanding complex systems … Complexity thinking is a revised philosophic stance that implies methodological pluralism in which both narrative and mechanical descriptions contribute to understanding complex systems. Neither alone is sufficient'. Haynes (2008: 402) also offers some hope of a practical solution to the apparent need to situate research "between two philosophical traditions: positivistic and post structuralism … complexity offers its own unique account of this methodological 'middle ground'". Kernick (2006: 388) suggests that it has 'insights for health service research … The insights and metaphors of complexity theory offer alternative frameworks for the development of qualitative investigation … [and] A wide range of quantitative approaches based on non-linear systems theory are being developed where the investigative focus is on the dynamics of systems rather than an artificial static'.

However, when we move from these promises towards more concrete studies we often find one of two things. First, we have post-hoc reasoning in which complexity themes are identified by reinterpreting previous work (Butler and Allan, 2008 are proponents of this approach). Second, we have research designs attached to predictions that seem to be too vague to allow the reader to challenge the findings. For example, Bovaird (2008: 326) makes the following predictions:

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- In a highly interactive system in which non-linear relationships determine outcomes, system interactions are likely to be highly unpredictable.
- In a fast-changing complex adaptive system, agents in the system are typically unable to exercise much control over the flow of events.
- Highly interconnected systems are more likely to operate as complex adaptive systems.

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- In attempting to alter 'the rules of the game' in a complex adaptive system, emergent strategic management approaches are more likely to be successful than traditional strategic planning.

Bovaird (2008: 330) then confirms such predictions in similarly broad ways. For example: 'In this fast-changing system, both local authorities and central government (including its auditors and inspectors) were 'swimming in a flow of events', over which they were unable to exercise as much control as they hoped'. As stated, any results of complexity studies are likely to be rather banal and not distinctive from the current body of evidence which could be described in a much more straightforward way.

More satisfying applications of complexity theory may require more collaboration between the sciences, to couch the processes in a language that it meaningful to all. But how straightforward is this process? We may identify four main problems.

The first issue refers to our philosophical language; our language to describe the nature of the real world (ontology), how we can know what we know about it (epistemology) and discussions regarding the way that we choose to analyse it (methodology). While these issues may be faced by all researchers who collaborate with each other and are forced, to whatever degree, to confront their respective assumptions about science, they might be

expected to arise more in collaborative work between social and natural or physical scientists. Further, they may be more significant in areas such as complexity theory if it is seen as an application of theory from natural to social science. For Haynes (2008: 402) there may be a particular tension if we maintain a strong dichotomy between positivism and interpretivism and associate the natural sciences with positivism. In this context the transfer of complexity theory to social science, 'has developed from questions about the relationship of material properties in science and the relationship between physical objects and processes, so therefore it can be argued by post structuralists and interpretativism that there are still fundamental problems of ontology when applying complexity methodology to social phenomena'. Further, as Mitleton-Kelly (2003: 25-6) suggests, we should be cautious about the value of complexity theory to the social sciences because human behaviour or 'the capacity to reflect and to make deliberative choices and decisions among alternative paths of action' makes the social world a different object of study than the natural or physical world. This might suggest that a different world or object of study requires a different approach regarding how we can know what we know about it and how we choose to study it.

On the other hand, complexity theory in many respects represents a rejection of the methods associated with positivism and, for example, the search for law-like behaviour. It is 'a philosophy of science derived from the natural sciences concerned with phenomena and events that cannot be explained by traditional positivistic scientific methods' (Haynes, 2008: 402). Such a statement still requires unpacking because the term 'positivism' may mean different things to different people. Further, and perhaps more importantly, there is still a difference in the object of study that needs to be addressed. Again, Haynes (2008: 402) signals some advance in awareness of the issue, focusing on the fundamental point about the relationship between structure and agency: 'Complexity accepts the inevitability that individuals are often subservient to social structures, but realizes that feedback from individuals, however small in power, can contribute in unpredictable ways to the future organization and representation of structures'. This is fairly standard stuff (perhaps in contrast to some discussion at APSA 2009 regarding the role of conscious and non-conscious agency (as found in bacteria)) and not dissimilar to discussions seeking to explain the power of norms or the constraints of institutions.

Although the structure/ agency discussion is not unproblematic, it at least suggests that there are people thinking seriously about how to overcome the wider philosophical issues regarding how we characterise and observe complex social systems. It also opens the door to mixed methods and projects which seek to produce lessons between them. The debate on the relationship between structures, rules, institutions and agency is central to the key questions in political science regarding who or what exercises power and why policy changes. It is also inextricably linked to the methods that we use to answer those questions. For example, when using complex systems theory and mathematical modelling to explain policy dynamics we may focus on the explanatory power of rules and norms that bind behaviour. When using an interpretive approach and qualitative methods we may focus on the links between meaning and individual action; the extent to which rules are understood differently and not followed uniformly. A mixed methods approach is therefore crucial to not only establish but also qualify the value of complexity theory in political science. The divide between quantitative and qualitative research in the social sciences has been compared to a religious or cultural divide that often undermines serious collaboration (Mahoney and Goertz, 2006: 227). It remains to be seen if the decision itself to collaborate negates much of this divide and if both 'sides' can combine methods while remaining reflective about possible differences in philosophical assumptions.

The second relates to our language in relation to methods. Consider, for example, the following description of an aspect of our project: 'Mathematically, networks can be used to describe complex political systems. The dynamics on the nodes and the interactions depend on the political system: both the topology of the network and the coupling between nodes can be modelled to reflect the structure of the system. Individuals might be highly connected and in strategically important positions which allow them to spread their ideas to large audiences, whereas individual members of the public might have a negligible influence on decision makers. This can be mathematically modelled by directed and weighted graphs. Our project seeks to model the effects of formal constitutional structures, institutions and practices to explore the extent to which ideas spread within and across political systems to produce policy change. The theory of complex networks and graph theory provides us with basic mathematical concepts to describe social and political systems. However, many of these concepts are currently used on a very fundamental level only; a successful application requires their further development and adaptation to the systems we want to describe.' While this description is understandable to most, the analytical processes involved may not be. This perhaps presents the largest practical dilemma regarding this type of coordinated effort. Put simply, if the application of such theory requires the involvement of a physical scientist trained in, and experienced in the use of, complex mathematical models and formulae plus the involvement of a qualitative researcher who has dedicated years to interviewing and participant observation, then neither can hope to master each other's techniques. It also remains to be seen if each can obtain a degree of proficiency in each other's techniques to have a meaningful conversation about how they relate to each other.

The third relates to the conceptual language that the physical and social sciences may share. Although many physical science analogies are used in the social sciences, the literature applied to the social sciences is relatively underdeveloped, while mathematical models often display a relative lack of detail on the operation of political systems (Weidlich, 2000: 35-6). This is a problem largely related to the lack of collaboration between physical and social scientists, exacerbated by the constraints of specialisation and numerous conceptual barriers to meaningful engagement. For example, although the term 'chaos' may be used in the social sciences to describe a sense of randomness and unpredictability, its use in the physical sciences is to denote a *deterministic* process and sensitivity to initial conditions, which resembles but it not the same as the study of path dependence in social science. Similarly, while Hall (1993) uses 'first order' to describe incremental change and 'third order' to describe profound policy change, in the physical sciences 'first order' refers to types of phase transition (such as from solid to gas) that are *not* relatively insignificant (indeed, the radical-incremental distinction may also not translate – hence my clumsy description '*not* relatively insignificant').

This lack of common understanding may extend to the study of complexity in two main ways. First, the assumptions made about how we define complexity theory may differ in different disciplines. Although we can identify common components in most discussions, the proliferation of definitions in the social sciences (Kernick, 2006: 386 reports 45 different definitions) suggests that considerable discussion is required to produce a common, workable concept. This is on top of the broader ontological question regarding whether or not complex systems actually exist in the social world (particularly since the alternatives – treating complexity as a metaphor or presenting instrumentalist *as if* arguments – seem less persuasive). Second, the focus of complexity theory in the physical sciences is to explain how networks of non-identical elements interact and combine to produce system-wide

behaviour without any obvious degree of central control (Mitchell, 2009: 4). This is relatively problematic in the study of political systems when the 'centre' is often the main object of study. Further discussion is required to illuminate the meaning of terms we use. For example, we may reject the idea of a 'centre' but also identify a relatively dense and connected part of a wider system (i.e. this is what we may understand as a centre). We may also say that a complex system is 'self-organising' but be careful to relate this to overall policy outcomes rather than formal relationships (see Cairney, 2010 for a discussion of existing confusion on this point).

The fourth obstacle relates to the language that academics and policymakers use. If we are to take the qualitative part of complexity theory research seriously then we may have to adapt our terms so that they make a degree of sense to the policymakers and policy participants that we observe and interview (noting that prominent researchers in the field question the value of interviews because people are not good analysts of themselves and ascribe to themselves too much agency). Or, we have to translate the words that they use to describe the meaning they attach to the complex system within which they operate. Neither task is particularly easy when we seek to marry the mathematical with the interpretive. While many adherents to interpretivism may be content to adopt the language of their subjects of study when revealing their research findings, this is not an option in such an interdisciplinary project.

Few participants, if any, use terms such as 'phase transition' or 'punctuated equilibrium'. Indeed, most are too involved in the policy process to step back and examine their role at the abstract level necessary to generalise from personal experiences. They may also have different interpretations of policy decisions and the extent to which they represent radical rather than incremental change (Cairney, 2007a; 2007b). Policymakers may be more likely to recognise and use some political science terms to describe the factors that influence their decisions and the degree of interdependence that they experience in policymaking environments. This includes terms such as: 'governance', in which central governments perceive the loss, or delegate control, of policy implementation to other governmental, quasi-governmental and private actors; 'supranationalism', in which international organisations such as the European Union become more influential on domestic decision-making processes; and 'globalisation', in which policymakers witness the effects of global economic, social and cultural integration. Pressure participants may also recognise the scope for 'venue shopping' when dissatisfied with policy decisions by one government, a 'bandwagon effect' when groups try to influence the same policy issue at the same time, and a shift from negative to positive feedback when policymakers pay disproportionate attention to an issue that they previously ignored (Jones and Baumgartner, 2005). However, even then, we may be worried about a shared understanding of such terms. The term 'governance' is a particular worry since it can mean everything and therefore nothing.

What a pilot qualitative project might look like.

A key question that links complexity theory to the study of political institutions and agenda setting is: what types of systemic outputs occur when its members follow the same basic rules, and what small changes in rules will produce profound changes in systemic behaviour? Cairney (2010) suggests that one of the most fruitful expositions of this process is contained in punctuated equilibrium theory (as promoted by Jones and Baumgartner, 2005; Baumgartner and Jones, 1993; Workman et al, 2009). This theory is particularly relevant because it employs much of the language of complexity theory to explain the shift in group-government relationships. The 'general punctuation hypothesis' demonstrates, in a study of information processing, that policy processes exhibit non-linear dynamics and punctuated

equilibria. Jones and Baumgartner (2005: 7) define information processing as the 'collecting, assembling, interpreting and prioritizing [of] signals from the environment'. Policymakers are effectively surrounded by an infinite number of 'signals', or information that could be relevant to their decisions (from, for example, interest groups, the media or public opinion). Since they are 'boundedly rational' (Simon, 1976) and do not have the ability to process all signals, they must simplify their decision-making environment by ignoring most (negative feedback) and promoting few to the top of their agenda (positive feedback).

Negative feedback may produce long periods of equilibrium since existing policy relationships and responsibilities are more likely to remain stable and policy is less likely to change when the issue receives minimal attention from policymakers (a feature of policy communities - Richardson and Jordan, 1979; Jordan and Maloney, 1997). Positive feedback may produce policy 'punctuations' because when policymakers pay a disproportionate amount of attention to an issue it is more likely that policy will change dramatically. This is particularly the case following a 'bandwagon effect' in which policymakers and interest groups at multiple levels of government all pay attention to an issue at the same time, often seeking to contribute to finding new ways to address old problems and challenge the right of one organisation to command policy responsibility. The 'selective attention' of decision-makers or institutions explains why issues can be relatively high on certain agendas, but not acted upon; why these powerful signals are often ignored and policies remain stable for long periods. Policymakers are *unwilling* to focus on certain issues, either because ideology precludes action in some areas, there is an established view within government about how to address the issue, or because the process of acting 'rationally' (making explicit trade-offs between a wide range of decisions) is often unpopular. They are also *unable* to give issues significant attention, because the focus on one issue means ignoring 99 others. Change therefore often requires a critical mass of attention to overcome the conservatism of decision-makers and shift their attention from competing problems (2005: 19-20; 48-51). If the levels of external pressure reach this tipping point, they cause major and infrequent punctuations rather than smaller and more regular policy changes: the burst in attention and communication becomes self-reinforcing; new approaches are considered, different 'weights' are applied to the same categories of information; policy is driven ideologically by new actors; and/ or the 'new' issue sparks off new conflicts between political actors (2005: 52; 69). Information processing is characterised by 'stasis interrupted by bursts of innovation' and policy responses are unpredictable and episodic rather than continuous (2005: 20).

If we adapt this approach further, we begin with the understanding that policy participants represent one part of a wider complex system. Further, we know that their understanding of both (a) their networks with, and dependence on other actors; and (b) their environment, are related strongly to the signals or information they send and receive. Yet, we know less about how they understand the nature of their environment and therefore how they act in that context; how they interpret and weigh the constraints that they face and the signals they receive. This level of detail, gathered using qualitative research, is essential to sophisticated mathematical models of sociodynamics (Weidlich, 2000: 36). While the Policy Agendas Project tells us which issues receive the most attention, how those issues are framed and the effects of agenda setting on the allocation of resources, we know less about *why* policymakers choose to act on particular signals but not others. For complexity theory the key to understanding this process may be the concept of rule-bound behaviour: what determines the extent to which actors follow rules associated with institutions or political norms?

A project based on the adoption of complexity theory, and which takes qualitative research seriously, would seek to model the rules of information processing and the effects of changes to those rules; when, for example, policymakers focus on new signals and seek information in different places or outwith the usual channels. It would use qualitative methods to produce detailed case studies on policy change, based on the premise that: (a) the modelling of complex systems requires us to set analytical boundaries on their scope (for example, between the system and its environment); (b) policymakers and pressure participants are well placed to identify these boundaries and assess the effects of their interdependence with other actors; and (c) the fundamental features of a complex system – the rules that its members follow – can best be understood using a mix of qualitative methods. For example, semi-structured interviews can be used to establish the basic 'rules of the game' when interest group and government actors trade information for influence. These rules include: the ground rules of consultation (such as the need to support a shared and agreed understanding of the policy problem under consideration, the conduct of participants when in discussions and the assurances they give about the extent to which they will keep those discussions confidential) and the 'rules of thumb' that policymakers use (such as at what level of government consultation takes place, who to consult first, which forms of expertise gathering and evidence-based policy measures are used and which sources of information carry the most weight). Interviewing participants may also help us identify the point at which policy changes non-incrementally and explore the reasons for change (although see below).

In addition, participant observation further illuminates our understanding of the less visible rules of information processing (such as when a source of information from one interest group or individual carries more weight than another, even if this is not acknowledged in interviews) and the factors that contribute to a change in the rules (such as a crisis or 'triggering event' and the influence of other actors in the complex system, such as successful lobbying by a particular group to change policymaker perceptions of the problem, or a change of government) and new ways of thinking about policy. Direct observation of policy participants gives the interviewer more awareness of the policymaking environment, more of an insight into how policymakers react to events, and therefore more knowledge to draw on when asking participants to reflect on their behaviour. This may be crucial if policy participants are too close to the process to reflect on how they are influenced by political norms and structures.

Many of the questions to be asked would follow the format of previous studies that I have been involved in (see for example Keating, Cairney and Hepburn, 2009; Cairney, 2008): Where in the political system are key decisions made? How do policy participants deal with issues of interdependence and overlaps of policy responsibility? How frequent and significant are interactions between policymakers and pressure participants? How receptive are policymakers to particular ideas? What are the most relevant socioeconomic factors and how are they weighted by policymakers? Why were policy decisions made and what was the significance of those decisions?[i] However, complexity theory requires additional information on the nature of networks (including their strength and frequency) between participants and their perception of the rules of consultation and information processing that are embedded within these networks.

Participant observation is also central to exploring the value of an interpretive approach to complexity, identifying not only the rules of information processing and policymaking but also how policymakers and participants understand the environment in which they operate.

In particular, it would help explore key tension points between mathematical and interpretive approaches to this issue: If complexity theory suggests that systemic behaviour emerges when its members follow the same basic rules, what are the implications if members in different jurisdictions have a different understanding of those rules? Does it mean that the network should be modelled to reflect these differences or that we have identified two separate complex networks (with each network forming part of the other's environment)? Further, if complexity theory models rule-bound behaviour in the absence of a 'centre', how does this explain the need for, for example, devolved governments and EU member states to modify their behaviour with reference to their intergovernmental relationships? In turn, mathematical modelling may be necessary to explore the longer term dynamics of such systems and address other potential deficiencies in qualitative research. Put simply, punctuations or phase transitions in public policy do not seem to be particularly frequent. Indeed, Baumgartner and Jones (1993) often use a 50 year time period to chart one major shift in problem definition. This suggests that unless we get lucky or very comfortable within our object of study then we will not be in the position to observe such processes first hand.

Conclusion

The paper began by describing a process of initial excitement generated by interdisciplinary discussions, followed by a more realistic take on the limits to such projects, and perhaps a third stage in which the excitement has gone and the lure of a return to single disciplines becomes stronger. It outlines the problems that we face when trying to define complexity theory, the theoretical problems we face when applying it to political science, and the methodological and practical problems that arise when we try to turn an idea into a concrete project. The problem, of course, with such an endeavour is that if we focus too much on the problems we may never engage in such research which could prove to be valuable. It is also difficult to get a sense of the size of the particular problems we face when researching complexity theory and the general problems of research that any academic faces when engaging in any project.

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[i] Although note that this isn't how I would ask the questions.